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(54) **PLANAR ILLUMINATION DEVICE**

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(52) **U.S. Cl.**
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(Continued)

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(56) **References Cited**

U.S. PATENT DOCUMENTS

9,097,825 B1 * 8/2015 Gupta G02B 6/0026
9,690,036 B1 * 6/2017 Hou G02B 6/005
(Continued)

FOREIGN PATENT DOCUMENTS

CN 203980007 U 12/2014
CN 204513001 U 7/2015
(Continued)

OTHER PUBLICATIONS

Japanese Office Action dated Aug. 27, 2019 for corresponding Japanese Application No. 2017-187834 and English translation.
(Continued)

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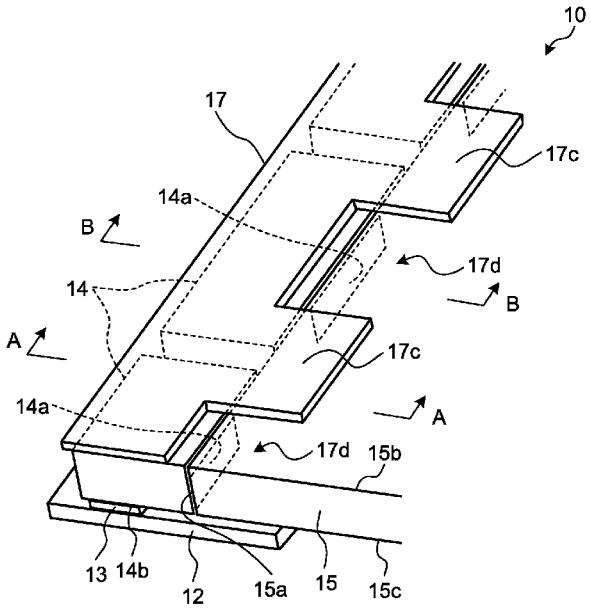
(57) **ABSTRACT**

A planar illumination device according to an embodiment includes a light guide plate, a substrate, a light source, a first fixing member, and a second fixing member. The light guide plate outputs, from a principal surface, light entering from a side surface. The substrate is disposed substantially in parallel with the principal surface of the light guide plate. The light source is provided on the substrate in a manner facing the side surface of the light guide plate. The light source has a light-emitting surface that outputs the light incident on the side surface. The first fixing member is disposed between the light guide plate and the substrate and fixes the light guide plate to the substrate. The second fixing member is disposed opposite to the first fixing member across the light guide plate and fixes the light guide plate to the light source.

18 Claims, 5 Drawing Sheets



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F21V 5/02 (2006.01)
G02B 5/02 (2006.01)
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(52) **U.S. Cl.**
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USPC 349/58–65
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(56) **References Cited**

U.S. PATENT DOCUMENTS

10,386,572	B1 *	8/2019	Wan	G02B 6/009
2004/0004424	A1 *	1/2004	Sakurai	G02B 6/0085 313/110
2009/0180054	A1 *	7/2009	Chen	G02F 1/133308 349/65
2011/0058121	A1 *	3/2011	Yabe	G02B 6/002 349/62
2015/0036385	A1	2/2015	Kawai	
2015/0219824	A1	8/2015	Kunimochi	
2015/0219943	A1 *	8/2015	Noh	G02F 1/13338 349/61
2015/0226913	A1 *	8/2015	Shimizu	G02B 6/0085 348/836
2015/0260909	A1 *	9/2015	Nambu	G02B 6/0068 362/613
2016/0216438	A1 *	7/2016	Kusunoki	G02B 6/0091
2016/0313487	A1 *	10/2016	Wang	G02B 6/009
2017/0176835	A1 *	6/2017	Gupta	G02B 6/0073
2017/0371095	A1 *	12/2017	Tokunaga	G02B 6/0088
2018/0003879	A1 *	1/2018	Furuta	G02B 6/0051
2018/0149800	A1 *	5/2018	Kim	G02B 6/0055
2018/0149922	A1 *	5/2018	Sugiyama	G02F 1/133308
2018/0173058	A1 *	6/2018	Yuki	G02F 1/133606
2018/0224595	A1 *	8/2018	Sugiyama	G02B 6/0088
2018/0259701	A1 *	9/2018	Yuki	F21S 2/00
2018/0321556	A1 *	11/2018	Watanabe	G02F 1/133615
2019/0056099	A1 *	2/2019	Shei	G09F 9/33

FOREIGN PATENT DOCUMENTS

JP	2006-040755	A	2/2006
JP	2011-060561	A	3/2011
WO	2016/204083	A1	12/2016

OTHER PUBLICATIONS

Decision to Grant a Patent dated May 15, 2020 for corresponding Japanese Application No. 2017-187834 and English translation.
First Chinese Office Action dated Aug. 14, 2020 for corresponding Chinese Application No. 201811066955.1 and English translation.
Second Chinese Office Action dated Jan. 18, 2021 for corresponding Chinese Application No. 201811066955.1 and English translation.

* cited by examiner

FIG.1

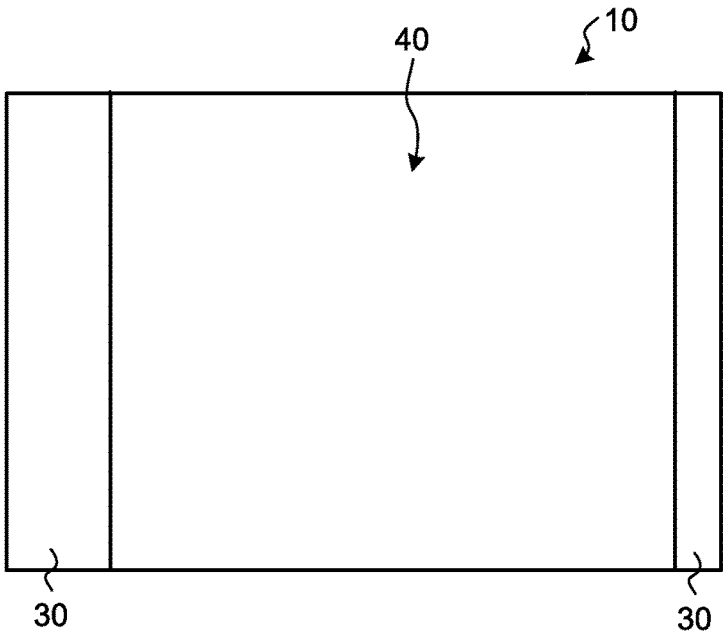

40
10
30
30

FIG.2

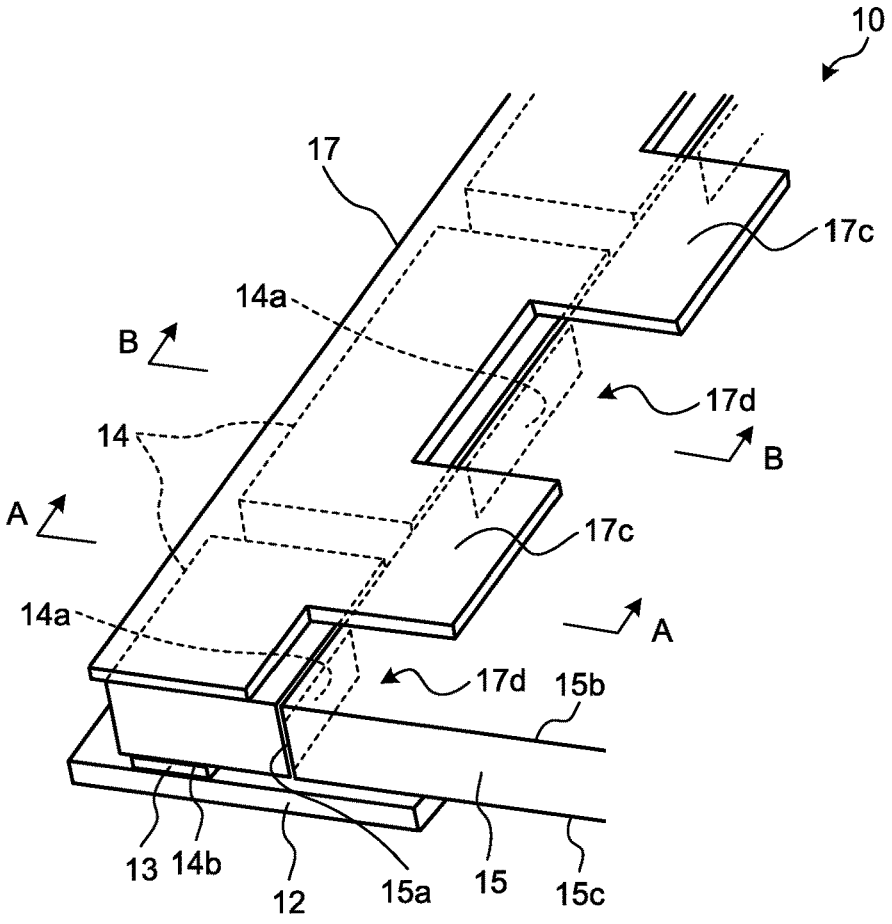

10
17
17c
14a
B
17d
14
B
A
17c
14a
A
17d
15b
13
14b
12
15a
15
15c

FIG.3

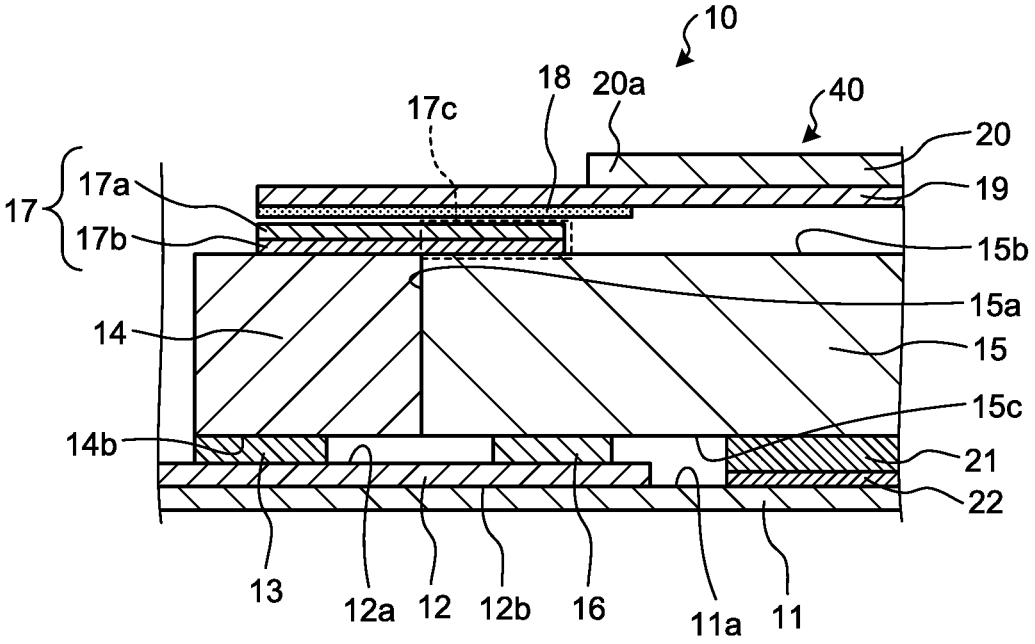
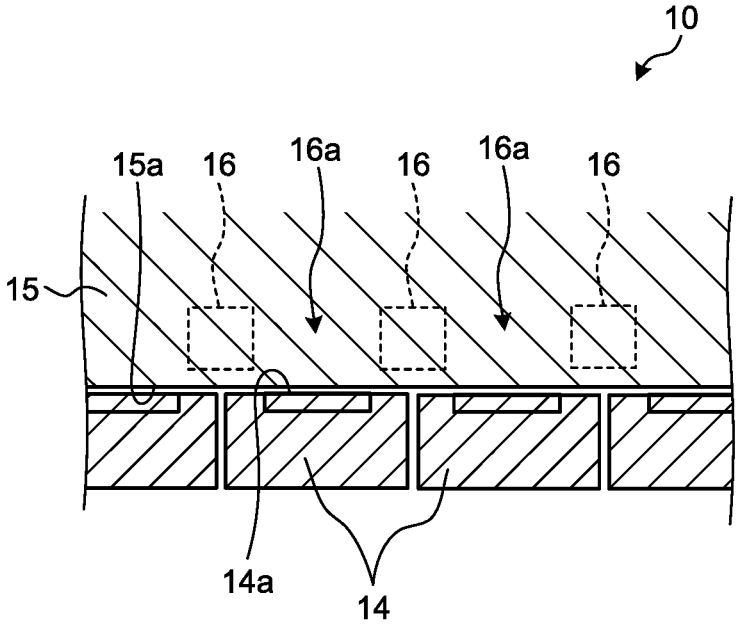

10
18
20a
40
17c
20
17
17a
19
17b
15b
15a
14
15
15c
14b
21
22
13
12a
12
12b
16
11a
11

FIG.4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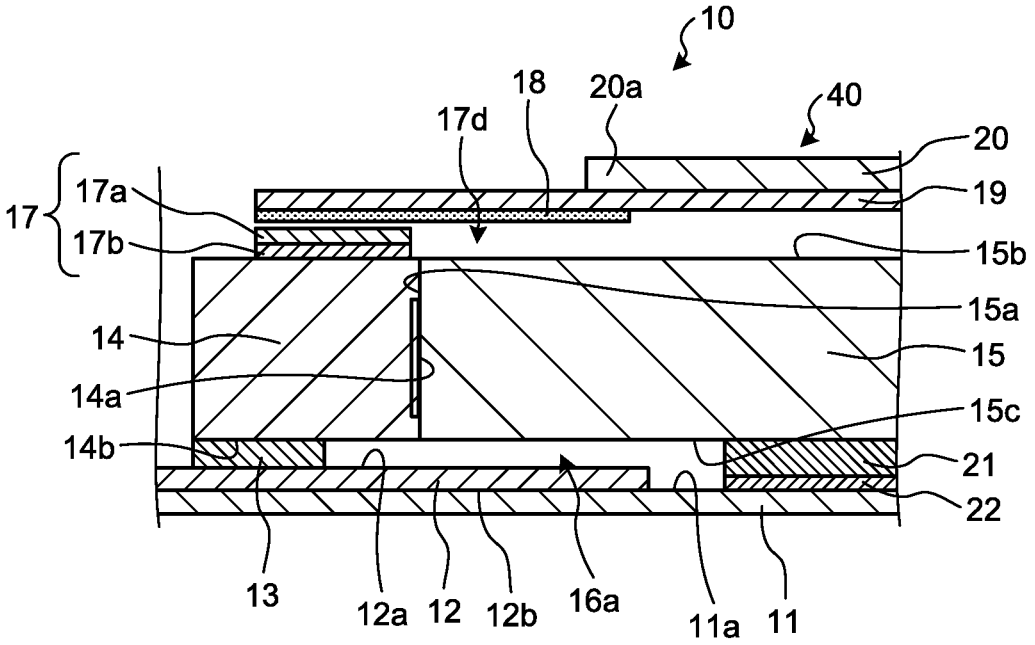
15a
16
16a
16
16a
16
15
14a
14

FIG.5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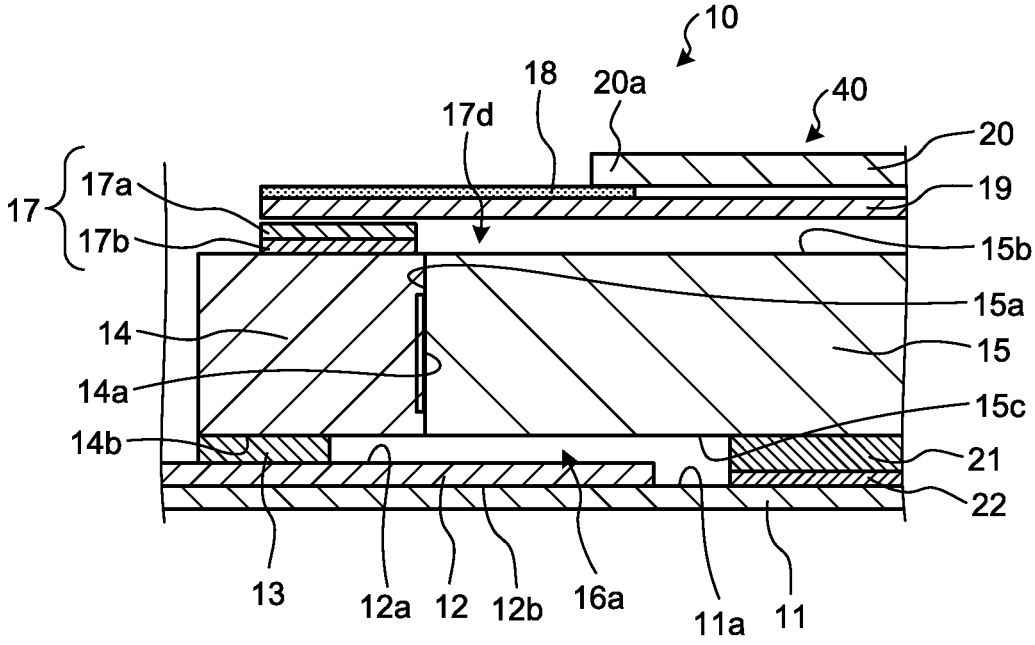
18
20a
40
17d
20
17
17a
19
17b
15b
15a
14
15
14a
15c
14b
21
22
13
12a
12
12b
16a
11a
11

FIG.6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18
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17a
19
17b
15b
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14
15
14a
15c
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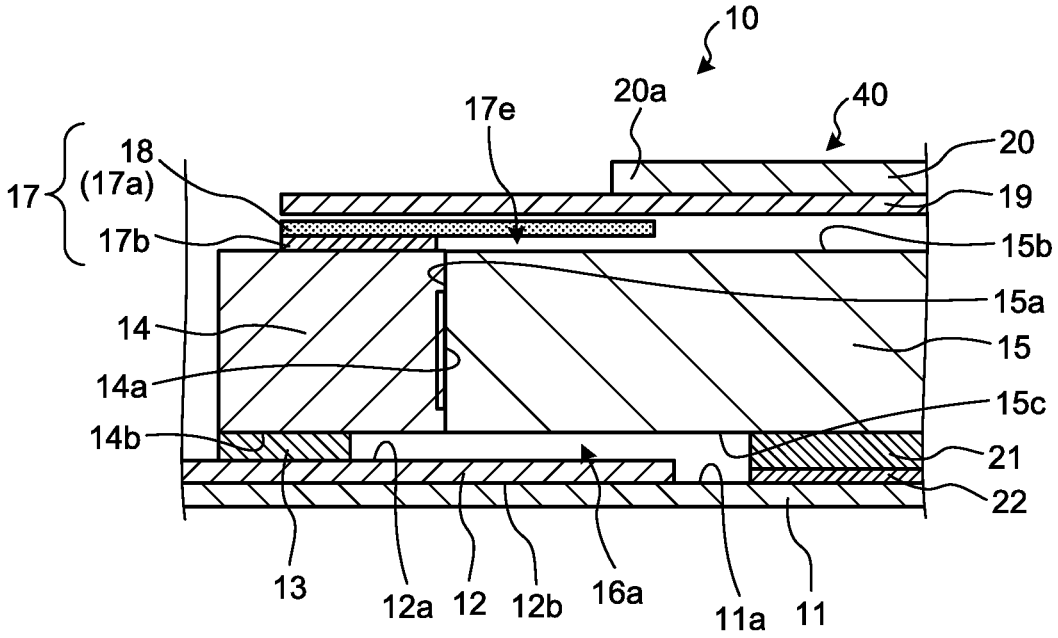
21
22
13
12a
12
12b
16a
11a
11

FIG.7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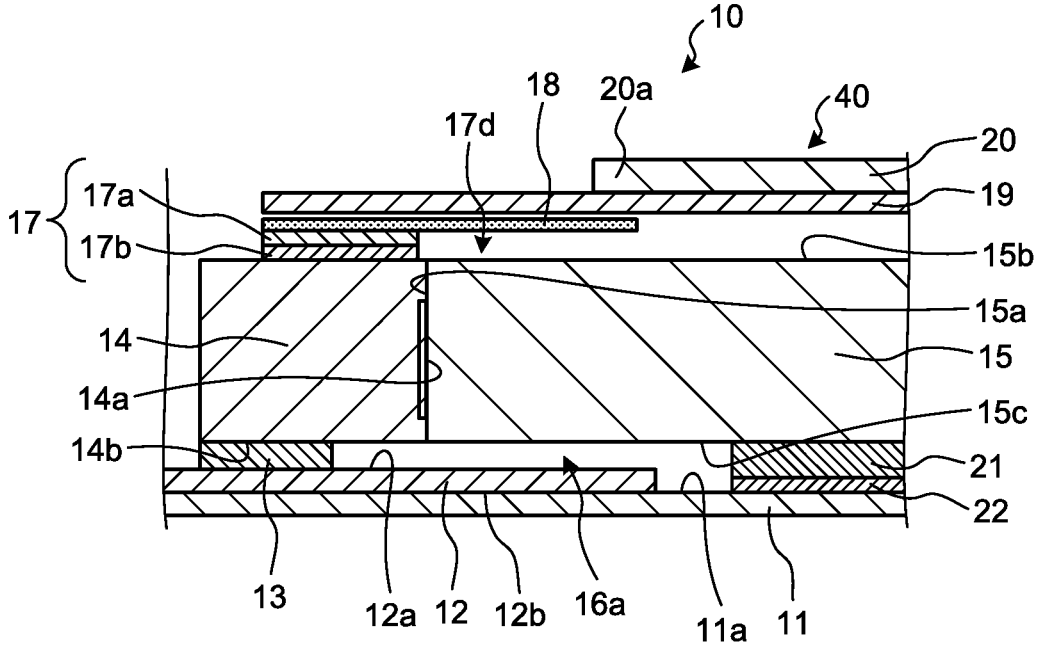
20a
40
17e
18
17
(17a)
17b
20
19
15b
15a
14
15
14a
15c
14b
21
22
13
12a
12
12b
16a
11a
11

FIG.8


10
18
20a
40
17d
20
17a
19
17
17b
15b
15a
14
15
14a
15c
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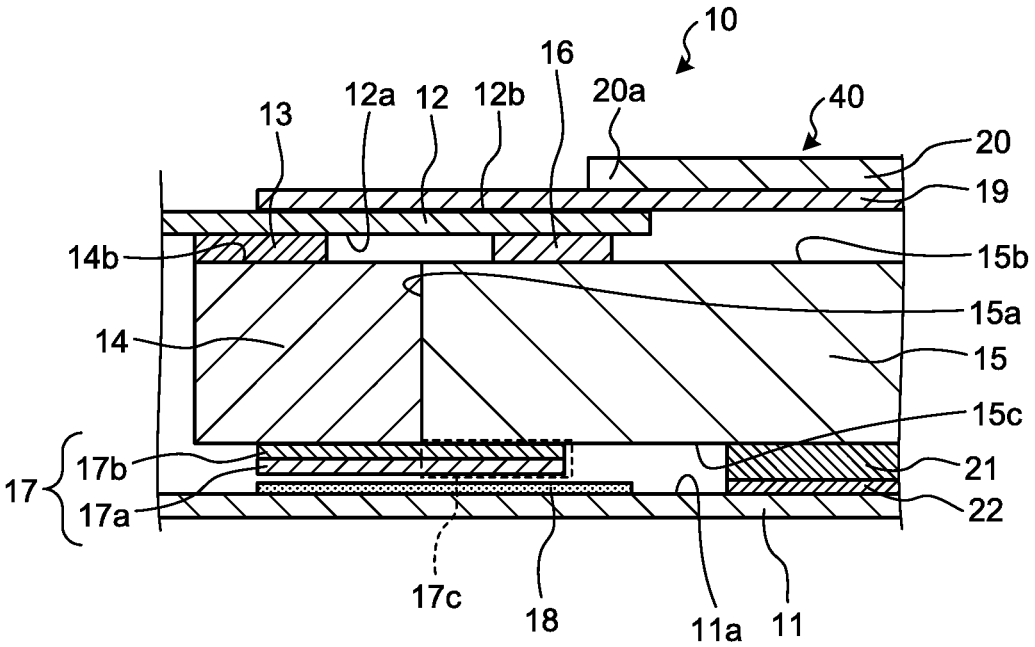
21
22
13
12a
12
12b
16a
11a
11

FIG.9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16
13
12a
12
12b
20a
40
20
19
14b
15b
15a
14
15
15c
17
17b
17a
21
22
17c
18
11a
11

PLANAR ILLUMINATION DEVICE

CROSS-REFERENCE TO RELATED APPLICATION(S)

The present application claims priority to and incorporates by reference the entire contents of Japanese Patent Application No. 2017-187834 filed in Japan on Sep. 28, 2017.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a planar illumination device.

2. Description of the Related Art

Widely known are edge-light planar illumination devices in which a side-view light emitting diode (LED) is disposed facing the side surface of a light guide plate. With recent demands for planar illumination devices having a narrower frame, downsizing of fixing members that fix the light guide plate to the LED has been required.

If such fixing members are downsized, however, a bonding area of the fixing members to the light guide plate is made smaller. As a result, force for fixing the light guide plate to the LED (hereinafter, referred to as fixing force) may possibly fail to remain strong enough to secure the reliability. If the fixing members fail to firmly fix the light guide plate to the LED with the optical axis of the LED aligned with the optical axis of the light guide plate, they may possibly have adverse effects on the luminance and the luminance distribution of the planar illumination device.

SUMMARY OF THE INVENTION

A planar illumination device according to an embodiment includes a light guide plate, a substrate, a light source, a first fixing member, and a second fixing member. The light guide plate has a side surface and a principal surface and outputs, from the principal surface, light entering from the side surface. The substrate is disposed substantially in parallel with the principal surface of the light guide plate. The light source is provided on the substrate in a manner facing the side surface of the light guide plate. The light source has a light-emitting surface that outputs the light incident on the side surface. The first fixing member is disposed between the light guide plate and the substrate and fixes the light guide plate to the substrate. The second fixing member is disposed opposite to the first fixing member across the light guide plate and fixes the light guide plate to the light source.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top view of an example of the appearance of a planar illumination device according to an embodiment;

FIG. **2** is a sectional perspective view for explaining the configuration of the planar illumination device according to the embodiment;

FIG. **3** is a sectional view along line A-A of FIG. **2**;

FIG. **4** is a top view illustrating arrangement of first fixing members according to the embodiment;

FIG. **5** is a sectional view along line B-B of FIG. **2**;

FIG. **6** is a sectional view of the planar illumination device according to a first modification of the embodiment;

FIG. **7** is a sectional view of the planar illumination device according to a second modification of the embodiment;

FIG. **8** is a sectional view of the planar illumination device according to a third modification of the embodiment; and

FIG. **9** is a sectional view of the planar illumination device according to a fourth modification of the embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Exemplary embodiments of a planar illumination device according to the present invention are described below with reference to the accompanying drawings. The embodiments described below are not intended to limit the use of the planar illumination device. The drawings are schematic representation, and the relation of the sizes of components, the ratio of the components, and other elements may possibly be different from those in the actual configuration. Furthermore, the drawings may possibly have portions where the relation of the sizes and the ratio are different.

Outline of the Planar Illumination Device

The following describes the outline of a planar illumination device **10** with reference to FIG. **1**. FIG. **1** is a top view of an example of the appearance of the planar illumination device **10** according to an embodiment. As illustrated in FIG. **1**, the planar illumination device **10** according to the embodiment outputs light from an active area **40** serving as an output region not covered with a light-shielding sheet **30**. In other words, the light-shielding sheet **30** defines the active area **40**.

The planar illumination device **10** according to the embodiment is used as a backlight of liquid crystal display devices. The liquid crystal display devices are used for smartphones, for example.

In FIG. **1**, the width of the left light-shielding sheet **30** is larger than that of the right light-shielding sheet **30**. This is because the right light-shielding sheet **30** covers a relatively small region not including a flexible printed circuit (FPC) **12** or an LED **14**, which will be described later, whereas the left light-shielding sheet **30** covers a relatively large region including the FPC **12** and the LED **14**. The width of the left light-shielding sheet **30** is 2.5 mm, for example.

Detailed Configuration of the Planar Illumination Device

The following describes the configuration of the planar illumination device **10** in greater detail with reference to FIGS. **2** to **5**. FIG. **2** is a sectional perspective view for explaining the configuration of the planar illumination device **10** according to the embodiment. FIG. **2** does not illustrate the components other than the FPC **12**, a solder **13**, the LED **14**, a light guide plate **15**, and a second fixing member **17**.

As illustrated in FIG. **2**, the planar illumination device **10** includes the FPC **12**, a plurality of LEDs **14**, and the light guide plate **15**. The LEDs **14** are disposed side by side along a side surface **15***a* of the light guide plate **15**. The LED **14** has a light-emitting surface **14***a* and a mounting surface **14***b*. The LEDs **14** are disposed side by side in the long-side direction of the side surface **15***a* with the light-emitting surface **14***a* facing the side surface **15***a* of the light guide plate **15**.

The LED **14** has a rectangular parallelepiped shape as a whole. The LED **14** is what is called a side-view LED having the light-emitting surface **14***a* perpendicular to the mounting surface **14***b* mounted on the FPC **12**.

The following describes component members of the planar illumination device **10** with reference to FIG. **3**. FIG. **3** is a sectional view along line A-A of FIG. **2** and illustrates a section of a portion not including the light-emitting surface **14***a* (refer to FIG. **2**) of the LED **14**. While FIG. **3** is a sectional view of FIG. **2**, it illustrates the section without omitting the component members not illustrated in FIG. **2**.

As illustrated in FIG. **3**, the planar illumination device **10** includes a frame **11**, the FPC **12**, the solder **13**, the LED **14**, the light guide plate **15**, a first fixing member **16**, the second fixing member **17**, a light-shielding member **18**, a diffusion sheet **19**, a prism sheet **20**, a reflection sheet **21**, and a double-sided tape **22**. The light-shielding sheet **30** illustrated in FIG. **1** is not illustrated in FIG. **3** and the drawings subsequent thereto.

The frame **11** is a member that accommodates the component members of the planar illumination device **10**. The frame **11** is a rigid frame, such as a stainless sheet metal frame. The frame **11** has a bottom surface **11***a*. The frame **11** may include a frame member made of resin and a bottom made of a light-shielding sheet or a graphite sheet with high thermal conductivity and having the bottom surface **11***a*, for example.

The FPC **12** is a substrate having a principal surface **12***a* and a back surface **12***b* and provided with the LED **14** on the principal surface **12***a*. The FPC **12** is provided with a predetermined wiring pattern (not illustrated). Electric power from an external power source (not illustrated) is supplied to the LED **14** via the wiring pattern, thereby causing the LED **14** to output light.

The FPC **12** is disposed substantially in parallel with a principal surface **15***b* of the light guide plate **15** between the bottom surface **11***a* of the frame **11** and the LED **14** and the light guide plate **15**. The back surface **12***b* of the FPC **12** is in contact with the bottom surface **11***a* of the frame **11**. The back surface **12***b* of the FPC **12** may be connected or not connected to the bottom surface **11***a* of the frame **11**.

The solder **13** electrically connects the wiring pattern provided on the principal surface **12***a* of the FPC **12** and the mounting surface **14***b* of the LED **14** and fixes the LED **14** to the FPC **12**.

The LED **14** is a point-like light source (point light source). The LED **14** is a pseudo-white LED including a blue LED and a yellow luminous body, for example. The LED **14** outputs light incident on the side surface **15***a* of the light guide plate **15**.

The light guide plate **15** is made of a transparent material (e.g., polycarbonate resin) and has a flat plate shape. The light guide plate **15** has the side surface **15***a*, the principal surface **15***b*, and a back surface **15***c* as the outer surface. The light guide plate **15** may have a wedge portion on the light entering side, for example.

The side surface **15***a* is an incident surface on which the light output from the LED **14** is incident. The principal surface **15***b* is an output surface from which the light entering from the side surface **15***a* is output outward. The back surface **15***c* opposite to the principal surface **15***b* is provided with an optical path change pattern including a plurality of dots, for example.

The optical path change pattern changes the traveling direction of light traveling in the light guide plate **15**, thereby efficiently outputting the light from the principal surface **15***b*. In other words, the planar illumination device **10** according to the embodiment is what is called an edge-light illumination device.

The first fixing member **16** is disposed between the principal surface **12***a* of the FPC **12** and the back surface **15***c* of the light guide plate **15** and fixes the light guide plate **15** to the FPC **12**. The first fixing member **16** is a double-sided tape, for example. One surface of the first fixing member **16** is bonded to at least part of the portion closer to the light guide plate **15** on the principal surface **12***a* of the FPC **12**, and the other surface thereof is bonded to at least part of the portion closer to the LED **14** on the back surface **15***c* of the light guide plate **15**.

The LED **14** is fixed to the FPC **12** with the solder **13**. The first fixing member **16** fixes the light guide plate **15** to the LED **14** with the FPC **12** and the solder **13**. The first fixing member **16** couples the light-emitting surface **14***a* of the LED **14** and the side surface **15***a* of the light guide plate **15** with the optical axis of the LED **14** aligned with the optical axis of the light guide plate **15**.

The second fixing member **17** is disposed opposite to the first fixing member **16** across the light guide plate **15** and fixes the light guide plate **15** to the LED **14**. The second fixing member **17** includes a base **17***a* and an adhesive layer **17***b*.

The base **17***a* is made of resin, such as polyethylene terephthalate (PET). The adhesive layer **17***b* is bonded to at least part of the portion closer to the light guide plate **15** on the surface of the LED **14** opposite to the mounting surface **14***b* and at least part of the portion closer to the LED **14** on the principal surface **15***b* of the light guide plate **15**. The second fixing member **17** couples the light-emitting surface **14***a* of the LED **14** and the side surface **15***a* of the light guide plate **15** with the optical axis of the LED **14** aligned with the optical axis of the light guide plate **15**.

The second fixing member **17** is a single-sided tape, for example. The second fixing member **17** is not limited to a single-sided tape and may be a double-sided tape, for example.

As described above, the embodiment includes two fixing members (the first fixing member **16** and the second fixing member **17**) on the principal surface **15***b* and the back surface **15***c* of the light guide plate **15** to fix the light guide plate **15** to the LED **14**. This structure has a larger bonding area of the fixing members to the light guide plate **15**. Consequently, the embodiment can increase the fixing force of the light guide plate **15** to the LED **14**.

If the second fixing member **17** is provided on the principal surface **15***b* of the light guide plate **15**, light is absorbed by an adhesive used for the adhesive layer **17***b* of the second fixing member **17** because the refractive index of the adhesive is close to that of the light guide plate **15**. As a result, the light emission efficiency of the planar illumination device **10** may possibly decrease.

To address this, the second fixing member **17** according to the embodiment has a plurality of protrusions **17***c* and cutouts **17***d* as illustrated in FIG. **2**. The protrusions **17***c* protrude toward the light guide plate **15**. The cutouts **17***d* are formed between the adjacent protrusions **17***c*. In other words, the second fixing member **17** has a comb shape.

As illustrated in FIG. **2**, the cutout **17***d* is formed on the side to which light is output from the light-emitting surface **14***a* with respect to the light-emitting surface **14***a* of the LED **14**. In other words, the second fixing member **17** is provided to the region other than the side to which light is output from the light-emitting surface **14***a* with respect to the light-emitting surface **14***a* of the LED **14**.

In other words, the adhesive layer **17***b* is provided between the adjacent LEDs **14** in a manner extending from a first end of the light-emitting surface **14***a* of a first LED **14** to a second end of the light-emitting surface **14***a* of a second LED **14** disposed side by side with the first end.

With this structure, the embodiment can prevent light output from the light-emitting surface **14***a* and entering into the light guide plate **15** from being incident on and absorbed by the adhesive layer **17***b* of the second fixing member **17**. Consequently, the embodiment can satisfactorily maintain the light emission efficiency of the planar illumination device **10**.

As illustrated in FIG. **4**, the first fixing member **16** according to the embodiment is also provided to the region other than the side to which light is output from the light-emitting surface **14***a* with respect to the light-emitting surface **14***a* of the LED **14**. FIG. **4** is a top view illustrating arrangement of the first fixing members **16** according to the embodiment.

As illustrated in FIG. **4**, for example, a plurality of island-like first fixing members **16** are disposed side by side facing respective boundaries between the adjacent LEDs **14**. Gaps **16***a* are formed between the adjacent first fixing members **16**. The gap **16***a* is formed on the side to which light is output from the light-emitting surface **14***a* with respect to the light-emitting surface **14***a* of the LED **14**.

With this structure, the embodiment can prevent light output from the light-emitting surface **14***a* and entering into the light guide plate **15** from being incident on and absorbed by an adhesive layer of the first fixing member **16**. Consequently, the embodiment can satisfactorily maintain the light emission efficiency of the planar illumination device **10**.

In the example illustrated in FIGS. **2** and **4**, the first fixing members **16** and the second fixing member **17** are disposed so as not to cover the front side of the light-emitting surface **14***a*. Alternatively, at least one of the first fixing members **16** and the second fixing member **17** may be disposed slightly covering the front side of the light-emitting surface **14***a*.

If the cutout **17***d* is formed on the side to which light is output from the light-emitting surface **14***a* with respect to the light-emitting surface **14***a* of the LED **14** as illustrated in FIG. **2**, the light output from the light-emitting surface **14***a* may possibly pass through the cutout **17***d* and leak to the outside. Examples of the leaking light include, but are not limited to, light not entering into the light guide plate **15**, light coming out from the principal surface **15***b* immediately after it enters into the light guide plate **15**, etc.

The leaking light may possibly cause a locally bright spot called a hot spot, thereby deteriorating the quality of light emission in the planar illumination device **10**.

To address this, the embodiment includes the light-shielding member **18** so as to cover the cutout **17***d* as illustrated in FIG. **5**. FIG. **5** is a sectional view along line B-B of FIG. **2** and illustrates a section of a portion including the light-emitting surface **14***a* of the LED **14**. While FIG. **5** is a sectional view of FIG. **2**, it illustrates the section without omitting the component members not illustrated in FIG. **2**.

With this structure, the light passing through the cutout **17***d* serving as an air layer is absorbed by the light-shielding member **18**. This structure can prevent the light passing through the cutout **17***d* from leaking to the outside. Consequently, the embodiment can satisfactorily maintain the quality of light emission in the planar illumination device **10**.

The light-shielding member **18** is a single-sided tape capable of shielding light, for example. The light-shielding member **18** is not limited to a single-sided tape capable of shielding light and may be a double-sided tape capable of shielding light, a tape capable of shielding light and provided with no adhesive layer, or a printed layer printed with an ink having a light-shielding property, for example.

The first fixing members **16** have the gaps **16***a* corresponding to the respective cutouts **17***d* of the second fixing member **17**, and light may possibly leak from the gaps **16***a*. The light leaking from the gaps **16***a*, however, does not leak to the outside because the FPC **12** that covers the gaps **16***a* from below has a light-shielding property.

The light-shielding member **18** according to the embodiment is bonded to the surface of the diffusion sheet **19** on the light guide plate **15** side in a manner facing the second fixing member **17** including the cutout **17***d*.

The diffusion sheet **19** is a member disposed on the principal surface **15***b* side of the light guide plate **15** to diffuse light output from the principal surface **15***b*. Specifically, the diffusion sheet **19** is disposed covering the principal surface **15***b* and at least part of the upper surface of the LED **14**.

The prism sheet **20** is disposed opposite to the light guide plate **15** across the diffusion sheet **19** in a manner covering the principal surface **15***b* of the light guide plate **15**. The prism sheet **20** is a member that performs light distribution control on light diffused by the diffusion sheet **19** and outputs the light resulting from light distribution control.

In the embodiment, it is preferable that an end **20***a* of the prism sheet **20** on the LED **14** side be disposed overlapping the light-shielding member **18**. If the end **20***a* of the prism sheet **20** does not overlap the light-shielding member **18**, light entering from the end **20***a* into the prism sheet **20** may possibly travel forward to be visually recognized as a bright line. The light may possibly deteriorate the quality of light emission in the planar illumination device **10**.

To address this, the end **20***a* of the prism sheet **20** according to the embodiment overlaps the light-shielding member **18**. This structure can prevent the bright line from being visually recognized. Consequently, the embodiment can satisfactorily maintain the quality of light emission in the planar illumination device **10**.

The reflection sheet **21** is a member that reflects light leaking from the back surface **15***c* of the light guide plate **15** and returns it into the light guide plate **15**. The reflection sheet **21** is disposed between the back surface **15***c* of the light guide plate **15** and the frame **11** and fixed on the bottom surface **11***a* of the frame **11** with a double-sided tape **22**.

One surface of the double-sided tape **22** is bonded to at least part of the reflection sheet **21**, and the other surface thereof is bonded to the bottom surface **11***a* of the frame **11**. As a result, the reflection sheet **21** is fixed on the bottom surface **11***a*.

Modifications

The following describes various modifications of the embodiment with reference to FIGS. **6** to **9**. FIG. **6** is a sectional view of the planar illumination device **10** according to a first modification of the embodiment. FIG. **6** is a drawing corresponding to FIG. **5** according to the embodiment.

In the first modification illustrated in FIG. **6**, the position of the light-shielding member **18** is different from that according to the embodiment. Specifically, the light-shielding member **18** according to the first modification is bonded to the surface of the diffusion sheet **19** opposite to the surface on the light guide plate **15** side in a manner facing the second fixing member **17** including the cutout **17***d* with the diffusion sheet **19** interposed therebetween.

This structure can prevent light passing through the cutout **17***d* from leaking to the outside. Consequently, the first modification can satisfactorily maintain the quality of light emission in the planar illumination device **10**.

FIG. **7** is a sectional view of the planar illumination device **10** according to a second modification of the embodiment. FIG. **7** is a drawing corresponding to FIG. **5** according to the embodiment.

In the second modification illustrated in FIG. **7**, the structure of the second fixing member **17** is different from that according to the embodiment. Specifically, the second fixing member **17** according to the second modification includes the light-shielding member **18** and the adhesive layer **17***b*. The light-shielding member **18** serves as the base **17***a*. The adhesive layer **17***b* is provided on the surface of the light-shielding member **18** on the light guide plate **15** side.

The second fixing member **17** according to the second modification has a portion provided with only the light-shielding member **18** and not provided with the adhesive layer **17***b*. The portion has a gap **17***e* not provided with the adhesive layer **17***b*.

In the second modification, the gap **17***e* is formed on the side to which light is output from the light-emitting surface **14***a* with respect to the light-emitting surface **14***a* of the LED **14**. In other words, the adhesive layer **17***b* is provided to the region other than the side to which light is emitted from the light-emitting surface **14***a* with respect to the light-emitting surface **14***a* of the LED **14**.

With this structure, the second modification can prevent light output from the light-emitting surface **14***a* and entering into the light guide plate **15** from being incident on and absorbed by the adhesive layer **17***b* of the second fixing member **17**. Consequently, the second modification can satisfactorily maintain the light emission efficiency of the planar illumination device **10**.

Similarly to the embodiment, the light-shielding member **18** according to the second modification is provided covering the gap **17***e*. This structure can prevent light passing through the gap **17***e* from leaking to the outside. Consequently, the second modification can satisfactorily maintain the quality of light emission in the planar illumination device **10**.

FIG. **8** is a sectional view of the planar illumination device **10** according to a third modification of the embodiment. FIG. **8** is a drawing corresponding to FIG. **5** according to the embodiment.

In the third modification illustrated in FIG. **8**, the position of the light-shielding member **18** is different from that according to the embodiment. Specifically, the light-shielding member **18** according to the third modification is provided on the surface of the base **17***a* of the second fixing member **17** opposite to the surface provided with the adhesive layer **17***b* in a manner covering the cutout **17***d*. In other words, the light-shielding member **18** according to the third modification is provided on the surface of the second fixing member **17** opposite to the surface on the light guide plate **15** side.

This structure can prevent light passing through the cutout **17***d* from leaking to the outside. Consequently, the third modification can satisfactorily maintain the quality of light emission in the planar illumination device **10**.

In the first to the third modifications, similarly to the embodiment, it is preferable that the end **20***a* of the prism sheet **20** on the LED **14** side be disposed overlapping the light-shielding member **18**. This structure can prevent light entering from the end **20***a* into the prism sheet **20** from traveling forward and being visually recognized as a bright line. Consequently, the first to the third modifications can satisfactorily maintain the quality of light emission in the planar illumination device **10**.

FIG. **9** is a sectional view of the planar illumination device **10** according to a fourth modification of the embodiment. FIG. **9** is a drawing corresponding to FIG. **3** according to the embodiment. In the fourth modification illustrated in FIG. **9**, the FPC **12** is disposed not on the back surface **15***c* side of the light guide plate **15** but on the principal surface **15***b* side. Specifically, the FPC **12** is disposed between the diffusion sheet **19** and the LED **14** and the light guide plate **15**. The back surface **12***b* of the FPC **12** is in contact with the surface of the diffusion sheet **19** on the light guide plate **15** side.

The first fixing member **16** according to the fourth modification is disposed between the principal surface **12***a* of the FPC **12** and the principal surface **15***b* of the light guide plate **15** and fixes the light guide plate **15** to the FPC **12**.

The second fixing member **17** according to the fourth modification is bonded to at least part of the portion closer to the light guide plate **15** on the surface of the LED **14** opposite to the mounting surface **14***b* and at least part of the portion closer to the LED **14** on the back surface **15***c* of the light guide plate **15**. In other words, similarly to the embodiment, the second fixing member **17** according to the fourth modification is disposed opposite to the first fixing member **16** across the light guide plate **15**.

As described above, the first fixing member **16** fixes the principal surface **15***b* of the light guide plate **15**, and the second fixing member **17** fixes the back surface **15***c* of the light guide plate **15**. This structure also has a larger bonding area of the fixing members to the light guide plate **15**. Consequently, the fourth modification can increase the fixing force of the light guide plate **15** to the LED **14**.

In the fourth modification, similarly to the embodiment, the light-shielding member **18** may be disposed covering the second fixing member **17** including the cutout **17***d* (refer to FIG. **2**) from below. This structure can prevent light passing through the cutout **17***d* from being reflected by the bottom surface **11***a* of the frame **11** and leaking to the outside. Consequently, the fourth modification can satisfactorily maintain the quality of light emission in the planar illumination device **10**.

While exemplary embodiments according to the present invention have been described, the embodiments are not intended to limit the invention. Various changes may be made without departing from the spirit of the invention. While the planar illumination device **10** according to the embodiment includes the LED **14** having one light-emitting surface **14***a*, for example, the LED **14** may have two or more light-emitting surfaces **14***a*.

As described above, the planar illumination device **10** according to the embodiment includes the light guide plate **15**, the substrate (FPC **12**), the light source (LED **14**), the first fixing member **16**, and the second fixing member **17**. The light guide plate **15** has the side surface **15***a* and the principal surface **15***b* and outputs, from the principal surface **15***b*, light entering from the side surface **15***a*. The substrate (FPC **12**) is disposed substantially in parallel with the principal surface **15***b* of the light guide plate **15**. The light source (LED **14**) is provided on the substrate (FPC **12**) in a manner facing the side surface **15***a* of the light guide plate **15**. The light source (LED **14**) has the light-emitting surface **14***a* that outputs the light incident on the side surface **15***a*. The first fixing member **16** is disposed between the light guide plate **15** and the substrate (FPC **12**) and fixes the light guide plate **15** to the substrate (FPC **12**). The second fixing member **17** is disposed opposite to the first fixing member **16** across the light guide plate **15** and fixes the light guide plate

15 to the light source (LED 14). Consequently, the embodiment can increase the fixing force of the light guide plate 15 to the LED 14.

In the planar illumination device 10 according to the embodiment, the second fixing member 17 includes the adhesive layer 17*b* bonded to the light source (LED 14) and the light guide plate 15. The adhesive layer 17*b* is provided to the region other than the side to which light is output from the light-emitting surface 14*a* with respect to the light-emitting surface 14*a* of the light source (LED 14). Consequently, the embodiment can satisfactorily maintain the light emission efficiency of the planar illumination device 10.

In the planar illumination device 10 according to the embodiment, a plurality of light sources (LEDs 14) are arrayed on the substrate (FPC 12). The adhesive layer 17*b* is provided between the adjacent light sources (LEDs 14) in a manner extending from a first end of the light-emitting surface 14*a* of a first light source (LED 14) to a second end of the light-emitting surface 14*a* of a second light source (LED 14) disposed side by side with the first end. Consequently, the embodiment can satisfactorily maintain the light emission efficiency of the planar illumination device 10.

The planar illumination device 10 according to the embodiment includes the light-shielding member 18 disposed covering the side to which light is output from the light-emitting surface 14*a* with respect to the light-emitting surface 14*a* of the light source (LED 14). Consequently, the embodiment can satisfactorily maintain the quality of light emission in the planar illumination device 10.

The planar illumination device 10 according to the embodiment includes the diffusion sheet 19 disposed covering the principal surface 15*b*. The light-shielding member 18 is provided on the diffusion sheet 19. Consequently, the embodiment can satisfactorily maintain the quality of light emission in the planar illumination device 10.

In the planar illumination device 10 according to the embodiment, the second fixing member 17 includes the base 17*a* and the adhesive layer 17*b*. The light-shielding member 18 is provided on the surface of the base 17*a* opposite to the surface provided with the adhesive layer 17*b*. Consequently, the embodiment can satisfactorily maintain the quality of light emission in the planar illumination device 10.

In the planar illumination device 10 according to the embodiment, the second fixing member 17 includes the light-shielding member 18 and the adhesive layer 17*b*. The adhesive layer 17*b* is provided on the surface of the light-shielding member 18 on the light guide plate 15 side. Consequently, the embodiment can satisfactorily maintain the quality of light emission in the planar illumination device 10.

The planar illumination device 10 according to the embodiment includes the prism sheet 20 disposed covering the principal surface 15*b*. The end 20*a* of the prism sheet 20 overlaps the light-shielding member 18. Consequently, the embodiment can satisfactorily maintain the quality of light emission in the planar illumination device 10.

In the planar illumination device 10 according to the embodiment, the second fixing member 17 is disposed on the principal surface 15*b* side. This structure enables the FPC 12 to be disposed on the back surface 15*c* side of the light guide plate 15. As a result, the FPC 12 can be fixed to the frame 11 in a simpler manner.

An aspect of the present invention can increase the fixing force of the light guide plate to the LED.

Although the invention has been described with respect to specific embodiments for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching herein set forth. light emission in the planar illumination device 10.

In the planar illumination device 10 according to the embodiment, the second fixing member 17 is disposed on the principal surface 15*b* side. This structure enables the FPC 12 to be disposed on the back surface 15*c* side of the light guide plate 15. As a result, the FPC 12 can be fixed to the frame 11 in a simpler manner.

An aspect of the present invention can increase the fixing force of the light guide plate to the LED.

Although the invention has been described with respect to specific embodiments for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching herein set forth.

What is claimed is:

1. A planar illumination device comprising:

a light guide plate having a side surface and a principal surface and that outputs, from the principal surface, light entering from the side surface;

a light source disposed in a manner facing the side surface of the light guide plate and having a light-emitting surface that outputs the light incident on the side surface; and

a fixing member that fixes the light guide plate to the light source, wherein

the light source includes a plurality of point light sources, each of which includes a light emitting area, thereby the light source including a plurality of light-emitting areas,

the fixing member includes a base and an adhesive layer bonded to the light source and the light guide plate,

the base has a plurality of cut-out portions in front of each of the point light sources and a plurality of protrusions provided to a region other than a side to which the light is output from the light-emitting areas of the light source, the cut-out portions and the protrusions formed in a comb shape,

the adhesive layer has a base portion collectively covering surfaces of the plurality of the point light sources, and a plurality of protrusions provided to the region other than the side to which the light is output from the light-emitting areas of the light source, the protrusions being formed in a comb shape, and

the protrusions of the adhesive layer are provided between adjacent light-emitting areas of the light source in a manner extending from a first end of a light-emitting surface of a first point light source to a second end of a light-emitting surface of a second point light source disposed side by side with the first end.

2. The planar illumination device according to claim **1**, further comprising a light-shielding member disposed covering the side to which the light is output from the light-emitting areas of the light source, the light-shielding member covering the cut-out portions of the fixing member, wherein

the fixing member is disposed on a principal surface side and fixes the light guide plate to the light source.

3. The planar illumination device according to claim **2**, wherein the light-shielding member is disposed covering at least part of the light source.

4. The planar illumination device according to claim **2**, further comprising:

a diffusion sheet disposed covering the principal surface and at least part of the light source, wherein

the light-shielding member is provided on the diffusion sheet.

5. The planar illumination device according to claim **2**, wherein the light-shielding member is provided on a surface of the base opposite to a surface provided with the adhesive layer.

6. The planar illumination device according to claim **2**, wherein the fixing member includes the light-shielding member and the adhesive layer, and the adhesive layer is provided on a surface of the light-shielding member on the light guide plate side.

7. The planar illumination device according to claim **2**, further comprising a prism sheet disposed covering the principal surface, wherein an end of the prism sheet overlaps the light-shielding member.

8. The planar illumination device according to claim **1**, wherein

the light-emitting area is respectively disposed at surfaces of each of the point light sources;

the fixing member includes a bar-shaped portion overlapped with the point light sources and the plurality of protrusions of the base provided to the region other than the side to which the light is output from the light-emitting areas of the point light sources, the cut-out portions and the protrusions of the base formed in a comb shape, and the protrusions of the base are extending from the bar-shaped portion toward the light guide plate in a plan view.

9. The planar illumination device according to claim **1**, wherein the adhesive layer provided to the region other than the side to which the light is output from the light-emitting area of each of the point light sources absorbs light entering into the light guide plate.

10. The planar illumination device according to claim **1**, wherein the adhesive layer of the fixing member is bonded to a part of a portion closer to the light guide plate on a surface of the light source in a manner not covering an edge of any surface of the light source opposite to the light-emitting surface of the light source.

11. The planar illumination device according to claim **1**, wherein the comb shape of the adhesive layer of the fixing member in a top view is substantially the same as the comb shape at the base of the fixing member.

12. The planar illumination device according to claim **1**, further comprising a substrate disposed substantially in parallel with the principal surface of the light guide plate, wherein

the plurality of the light-emitting areas are arrayed on the substrate, and

the surface collectively covered by the base portion is a surface opposite to a mounting surface of the light source that is mounted on the substrate.

13. The planar illumination device according to claim **1**, further comprising a substrate on which the light source is disposed, wherein the fixing member does not contact with the substrate.

14. A planar illumination device comprising:

a light guide plate having a side surface and a principal surface and that outputs, from the principal surface, light entering from the side surface;

a light source disposed in a manner facing the side surface of the light guide plate and having a light-emitting surface that outputs the light incident on the side surface;

a fixing member that fixes the light guide plate to the light source, and

a substrate on which the light source is provided is disposed only on a surface side opposite to a principal surface side, wherein

the light source includes a plurality of point light sources, each of which includes a light emitting area,

the fixing member includes a base and an adhesive layer bonded to the light source and the light guide plate,

the base has a plurality of cut-out portions in front of each of the point light sources and a plurality of protrusions provided to a region other than a side to which the light is output from the light-emitting areas of the light source, the cut-out portions and the protrusions formed in a comb shape,

the adhesive layer has a base portion collectively covering surfaces of the plurality of the point light sources, and a plurality of protrusions provided to the region other than the side to which the light is output from the light-emitting areas of the light source, the protrusions being formed in a comb shape,

the fixing member is disposed on the principal surface side,

the light source includes a light emitting diode (LED), and

the adhesive layer is directly bonded to the principal surface of the light guide plate and to a surface of the LED opposite to the mounting surface that is mounted on the substrate.

15. The planar illumination device according to claim **14**, further comprising another fixing member disposed between the light guide plate and the substrate and that fixes the light guide plate to the substrate, wherein the another fixing member is provided to a region other than the light-emitting areas of the light source.

16. The planar illumination device according to claim **14**, wherein

the light emitting area are respectively disposed at surfaces of each of the point light sources;

the fixing member includes a bar-shaped portion overlapped with the point light sources and a plurality of protrusions provided to the region other than the side to which the light is output from the light-emitting areas of the point light sources, the cut-out portions and the protrusions formed in a comb shape, and the protrusions are extending from the bar-shaped portion toward the light guide plate in a plan view.

17. The planar illumination device according to claim **14**, wherein the fixing member does not contact with the substrate.

18. The planar illumination device according to claim **14**, wherein the comb shape of the adhesive layer of the fixing member in a top view is substantially the same as the comb shape eat the base of the fixing member.

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